

SOLVE-II Flight Report: Tuesday, 02/04/2003

Mark R. Schoeberl

Flight Type: PSC Hunt, Inter-Calibration and Vortex Probe

Flight Objectives:

1. Voyage to Mini-Hole to look for PSCs
2. Inter-calibration flight
3. Cross vortex scan

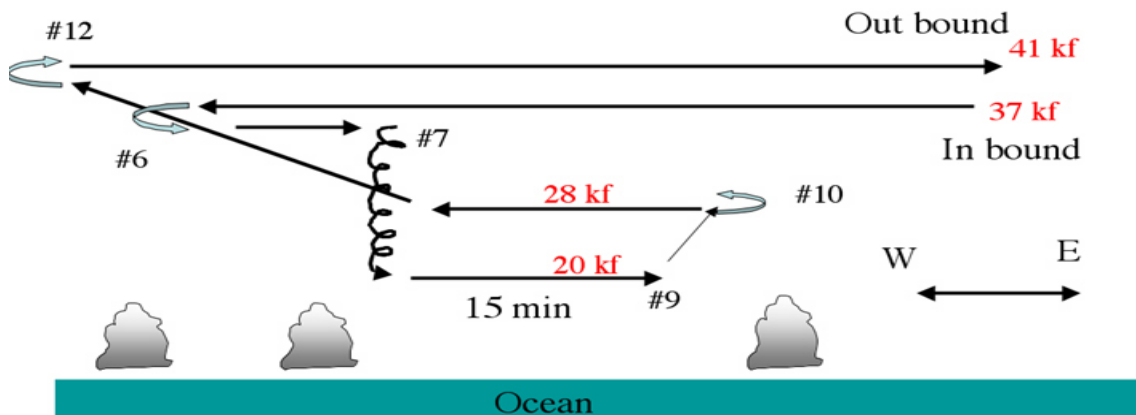
Flight Plan (UT):

5:15 Takeoff
6:24 West end look for PSCs just off Iceland
7:29 Begin calibration maneuvers
8:44 End calibration maneuvers
10:51 Land

Flight Plan Discussion

A tropospheric uplift event is occurring at the edge of the vortex that will generate temperatures near 195K. In addition this region will be a source of intense gravity wave activity off Greenland. We plan to go see if PSCs form in the lee waves. Because the temperature lidar will not operate at zenith angles less than 94° we will take off very early and race the sun to Iceland. On the way back we plan to do some descent and back track maneuvers to inter-calibrate the instruments. The plan for these maneuvers are shown below.

Detail of Descent Maneuver



These maneuvers will take place in forecast clear-air regions. Since there are no sun runs, the solar instruments will not be operated during this flight.

Flight Report:

Takeoff 5:14 UT, ozone ~50 ppbv, CO 150 ppbv, H₂O 120 at 20 kft. Surface temperature -5°C. Gravity wave models predict some chop off Norway – confirmed shortly into the flight. On the climb out, DIAPER reports in situ cirrus clouds, CN, and MTP trop shows at 10 km. DIAL sees cirrus at the tropopause. At 32 kft, ozone was 13, CO 142, and H₂O 16.

At 37 kft, ozone was 231, CO 48, and H₂O 9.1. Flew through a chunk of high ozone air as we flew west, anti-correlated with CO and water. We are inside the vortex at takeoff; ozone at 20km is 1.8 ppmv. MTP shows temperatures at 20 km of ~200K; AROTAL is 197K at 20 km just off the coast of Norway. Temperatures began to decline at 18 km as we flew to Iceland. We climbed to 37 kft, and ozone was 250, CO 45, H₂O 8. We were cleared to 39 kft. Ozone was 400, CO 29, and H₂O 3.9. DIAL reported sloping aerosol layers at WP4, 15 km. AROTAL temperatures are 195K.

Today is Bill Grant's birthday – we all sang “Happy Birthday” over the headsets to him.

AROTAL reported two beautiful filaments of ozone short of WP5 – the second one was about 120 km wide. Temperatures decreased to 193K at WP5 at 19 km. Ozone was 485, CO 24, and H₂O 3.4. Approaching WP6, the plane began to experience some gravity-wave activity.

Ozone showed significant structure and flight-level winds increased rapidly as we approached the jet. Temperatures were at 192K. A layer began to form at 19 km – also a layer between 16 and 18 km. In situ ozone structure continued to show significant variability as we approached the jet core. The ozone structures have a horizontal wavelength of 84 km. AROTAL temperatures were between 192 and 193K in the 18-km region. An aerosol layer developed between 16 and 18 km, with several distinct layers separated by about 1 km.

The region covered from WP5 to WP6 had cloud tops below 20 kft according to DIAL, so we did not have to change our maneuvers. At WP6, ozone was 490, CO 25, and H₂O 3.5. There was no evidence of PSCs, but swollen aerosols were observed. At 7:30 we began our descent to 20 kft in a spiral. In situ ozone fell rapidly, and CO and H₂O rose as we descended; there was a lot of structure in both fields. SP-2 shows CN increases, but volatile fraction decreases, and an increase in incandescent particles as we went below the tropopause. MTP reports the tropopause altitude at about 32 kft (10 km).

At the bottom of the spiral descent, ozone was 46, CO 155, and H₂O 108. DIAPER and SP2 saw some nice structure during the descent, but aerosols at 20 kft were pretty low. PANTHER saw methyl bromide increase at the lower altitudes. Lots of structure in CO,

but little structure in ozone observed. Went through an aerosol layer at 28 kft, 24 kft, and 21 kft. AROTAL could see those layers as we backtracked. AROTAL reported minimum temperature at 194 and an aerosol enhancement at the same altitude. The ozone gradient was pretty flat in the 16- to 20-km region. We climbed to 28 kft and returned toward the jet. Ozone was 52, CO 130, and H₂O 13. We asked the pilots to fly 60 km further toward the jet before the return leg. Clear trop fold below the plane that we flew through on the inward leg; with this strong a jet acceleration, we expect that the ageostrophic circulation would create a strong fold. We ascended to 41 kft with lots of ozone structure. As we approached WP12, DIAL detected cirrus below the aircraft. The intercalibration flights went without a hitch. This data will be very useful for the lidars and the in situ guys.

At the end of WP12a, we observed a PSC over Iceland as the sun rose. The pilots got permission to underfly the PSC, causing us to divert south over Iceland; we then turned northeast to underfly the PSC. The PSC was located over Hornafjord, Iceland at about 22 km. Temperatures were 190K approaching the cloud, but as the sun was rising, their data became more unreliable. The cloud was definitely Type II. MTP reports the tropopause at 38 kft shortly after we underflew the PSC. After the lidars reported no more activity, we turned back toward Kiruna. DIAL reports a trop fold below the aircraft.



Figure 1. PSC over Iceland during sunrise. The pilots turned the plane and underflew this PSC. Photograph by Mark Schoeberl.

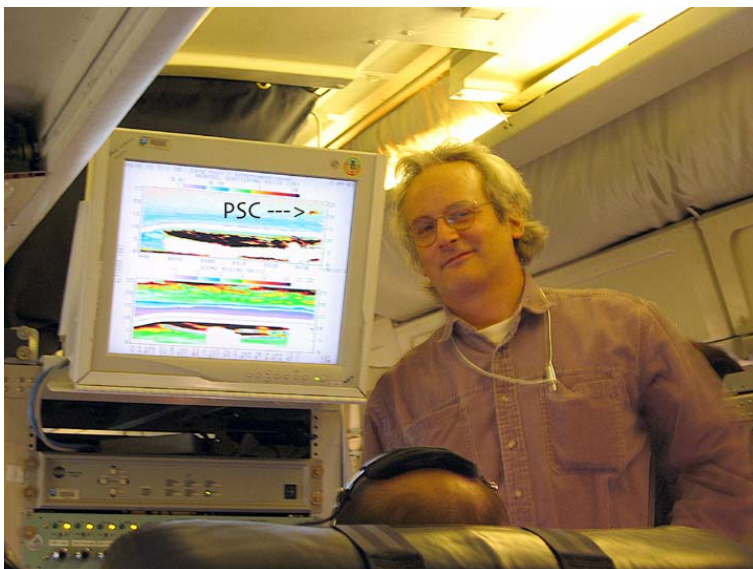


Figure 2a. Rennie Selkirk, our mission meteorologist, grins next to DIAL console just after we underflew the PSC. The DIAL display shows the PSC (see arrow).

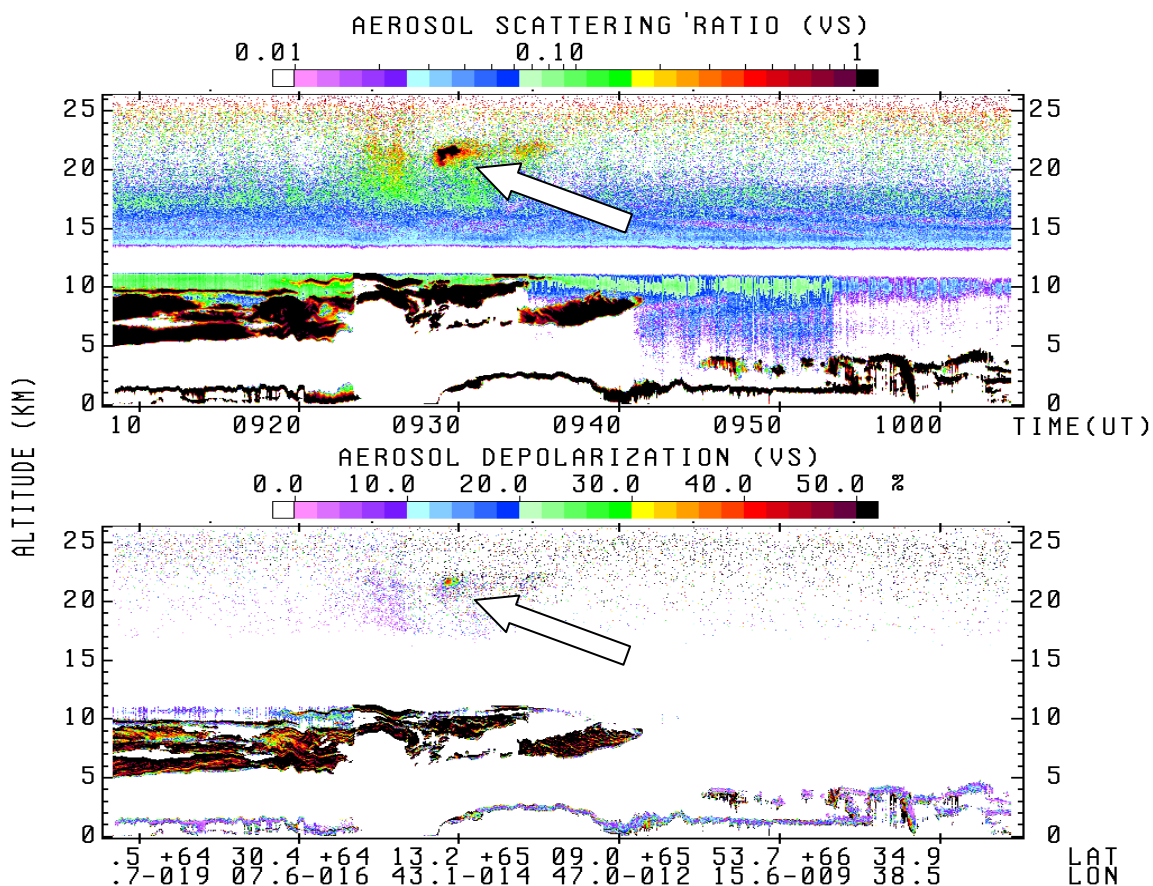


Figure 2b. DIAL data showing the PSC in the upper picture (20 to 21 km) at 9:30. The lower picture shows that the PSC was depolarizing, which means it contained ice crystals. (See arrows)

Returning toward Kiruna, AROTAL saw more filaments of ozone near 22km and somewhat higher ozone values at 20 km. At 41kf O3:552, CO 23, H2O 3.2. These are very low water vapor values. AROTAL showed a lot of structure in ozone with values at 20 km of more than 2 ppmv. In situ O3 began to decline. O3:502, CO: 22.4, H2O:3.3.

As we came in over Kiruna we began a spiral descent. Cirrus was present at 33 kft – roughly the height of the tropopause. Ozone decreased rapidly as CO and H2O rose. Cirrus was thin enough that AROTAL could keep transmitting – DIAPER also confirmed the thin cirrus. Landing at 12:13:49.

Pilots: Ed Lewis & Dick Ewers
Navigator: Kevin Hall
Mission Managers: Chris Miller & Tom Mace
Mission Scientist onboard: Mark R. Schoeberl

Status Report: Instrument – PI

DIAPER (in situ aerosols) – Anderson
Good flight. Everything worked. Loved the spiral down – lots of CN structure and layers.

SP2- (Baumgardner) Had a good flight. Worked well; saw a lot of stuff.

FastOz – Avery
Instrument had a good flight. Saw a great tropopause fold on descent.

DACOM/DLH (in situ trace gases and open path water vapor) – Diskin
Lots of good data.

PANTHER (in situ PAN and other trace gases) – Elkins
Clearly saw lots of tropospheric molecules show gradients.

MTP (microwave temperature profiler) – Mahoney
Tropopause went way up on west side of jet.

AATS-14 (sun photometer) – Russell
Not operated

GAMS/LAABS (solar occultation ozone, aerosols, and oxygen A band) – Pitts
Not operated

DIAL (Lidar ozone and aerosol above and below the AC) – Browell
Worked well. Saw gravity waves, saw PSCs and trop folds. Good comparisons with FastOz.

AROTAL (Lidar ozone, aerosols and temperature above the AC) - McGee/Hostetler
GSFC – Great flight everything worked. Saw cold temperatures near PSC. Saw gravity waves in temperature field.
LaRC – Great flight.

ICATS – Good Flight.

DIAS (Direct beam solar irradiance) – Shetter
Not operated.

FCAS/NMASS (in situ aerosols) – Reeves
Automated.

Differential GPS – Muellerschoen
Worked fine,

Plots (flight plan, solar zenith angles, relative humidity):

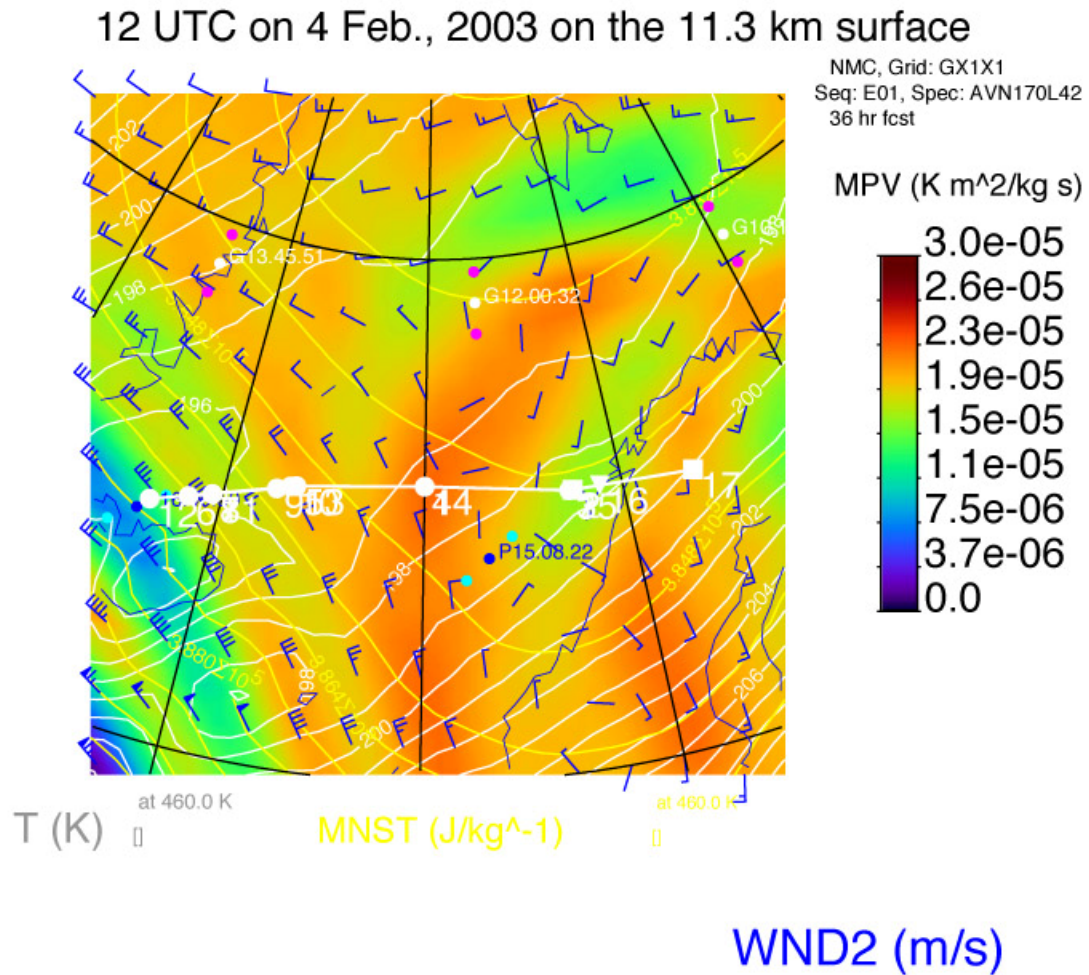


Figure 3. 4 February 2003 DC-8 flight plan (white) superimposed on a 12Z map of modified potential vorticity (color image) for the 460K isentropic surface. The thick magenta line on the left shows the 200- and 205-K temperature contours. The white point indicates the SAGE III occultation point and the dark blue points are POAM occultation points. The white lines are Montgomery stream function lines (winds blow parallel of these line) and temperature (K). The blue wind barbs show the wind at 460K.

12 UTC on 4 February, 2003

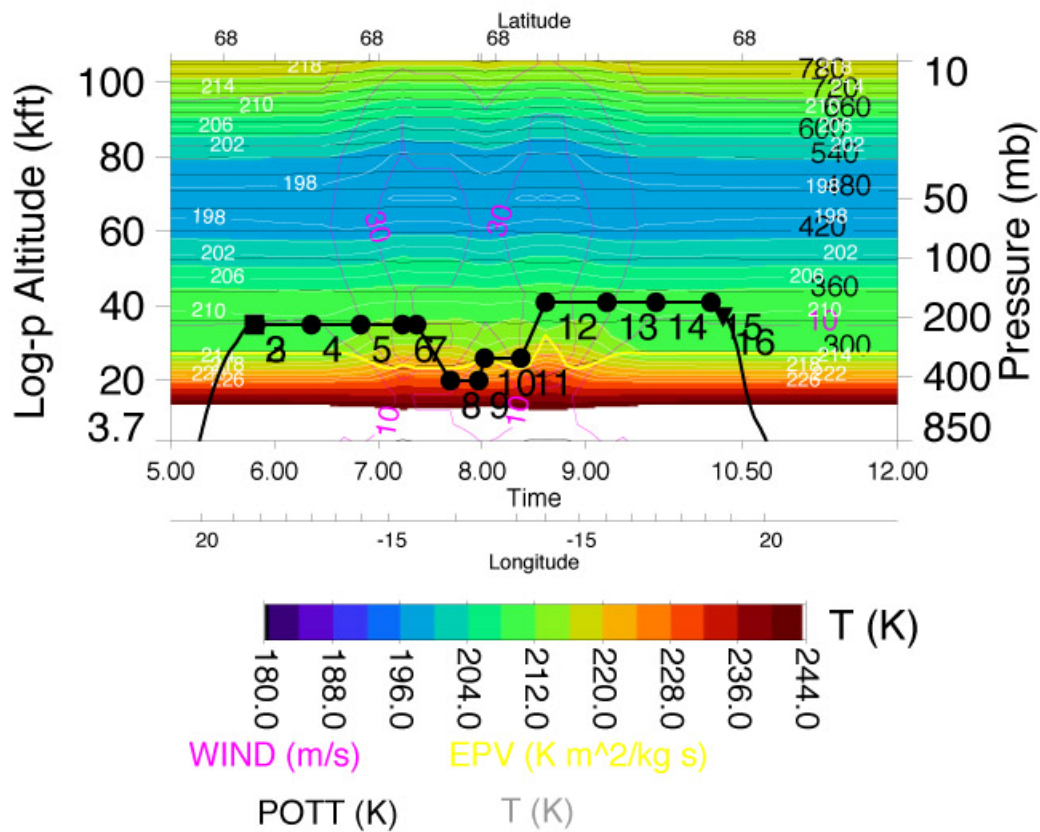


Figure 4. Curtain plot following the flight of 4 February 2003. The colors indicate temperature values (see scale at bottom of the figure and contours). Purple contours are wind speed in m/s

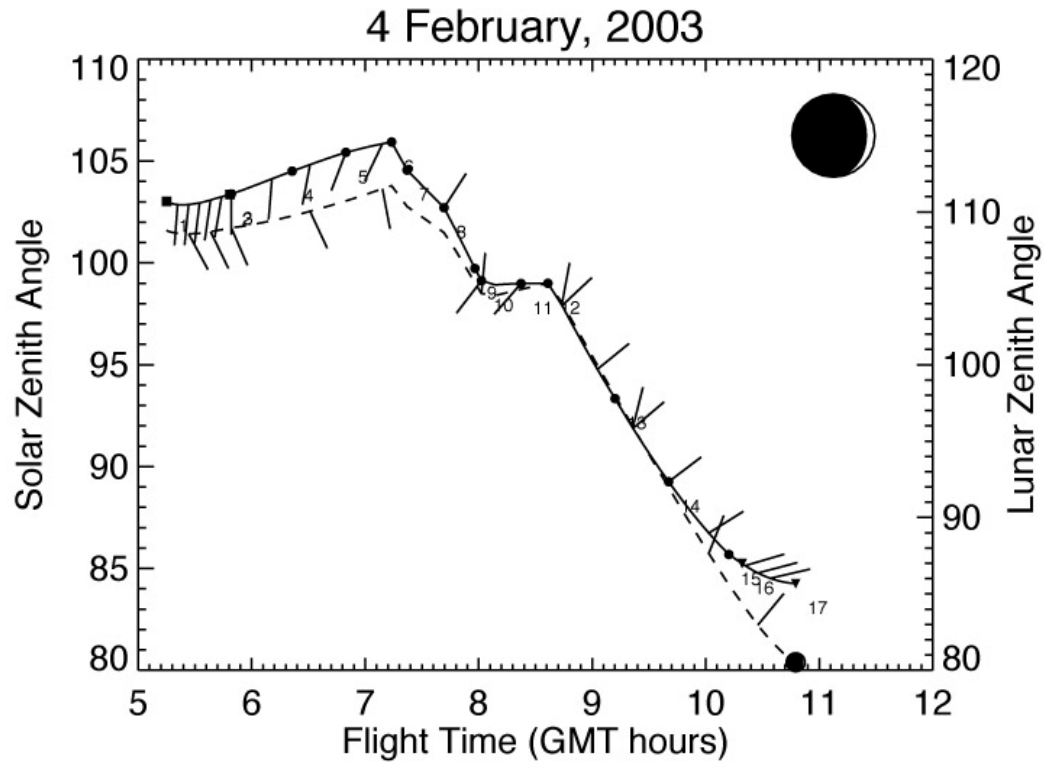


Figure 5. Solar and lunar zenith angles for the flight path shown in the previous figures.

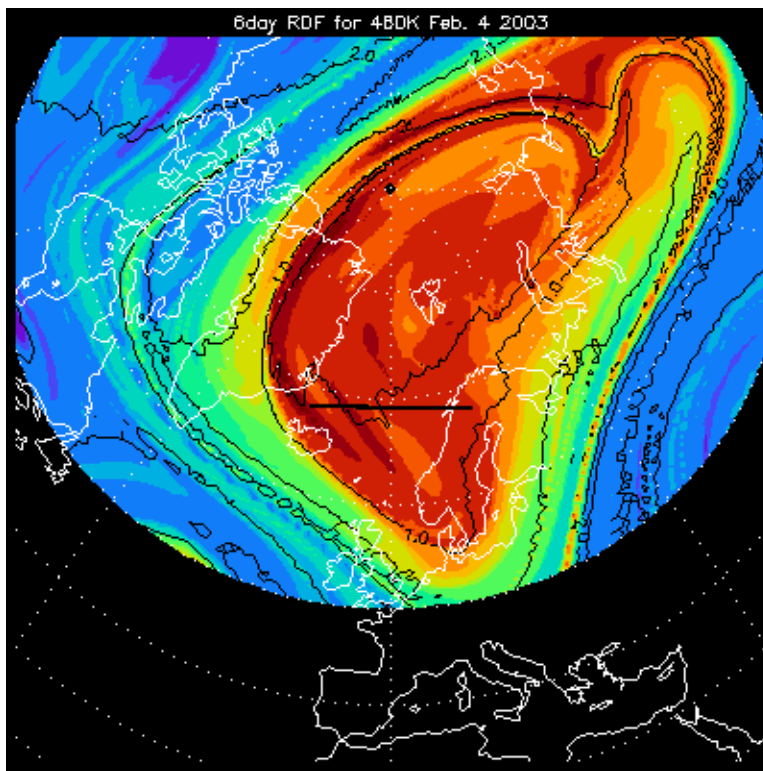


Figure 6. Six-day RDF of the vortex using Data Assimilation Office data black line indicates the flight track. Colors indicate high PV values (red) to low (blue).

12 UTC on 4 Feb., 2003 on the 11.3 km surface

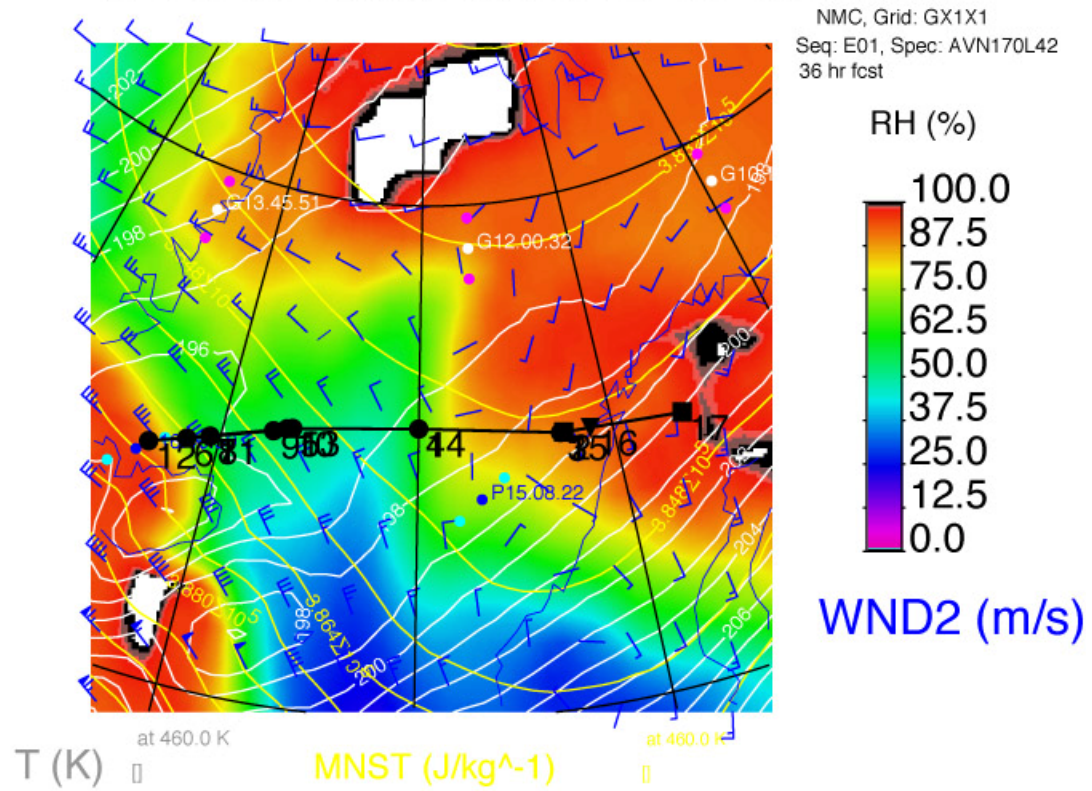


Figure 7. Relative humidity plots for flight level 37 kft. The dark blue and black areas show high relative humidity. Flight track is in black. Barbs are flight level winds.